U.S. Spacesuit Knowledge Capture Accomplishments in Fiscal Year 2014

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Since its 2008 inception, the NASA U.S. Spacesuit Knowledge Capture (KC) program has shared historical spacesuit information with engineers and other technical team members to expand their understanding of the spacesuit's evolution, known capability and limitations, and future desires and needs for its use. As part of the U.S. Spacesuit KC program, subject-matter experts have delivered presentations, held workshops, and participated in interviews to share valuable spacesuit lessons learned to ensure this vital information will survive for existing and future generations to use. These events have included spacesuit knowledge from the inception of NASA's first spacesuit to current spacesuit design. To ensure that this information is shared with the entire NASA community and other interested or invested entities, these KC events were digitally recorded and transcribed to be uploaded onto several applicable NASA Web sites. This paper discusses the various Web sites that the KC events are uploaded to and possible future sites that will channel this information.

Nomenclature

BCM	=	Baylor College of Medicine
CS	=	crew survival
CTSD	=	Crew and Thermal Systems Division
DAA	=	Document Availability Authorization
EA	=	Engineering Directorate
EC	=	Crew and Thermal Systems Division
ECLSS	=	Environmental Control and Life Support System
EMU	=	Extravehicular Mobility Unit
EVA	=	extravehicular activity
FY	=	Fiscal Year
ICES	=	International Conference on Environmental Systems
ISS	=	International Space Station
JSC	=	Johnson Space Center
KC	=	knowledge capture
K-CAP	=	knowledge capture [lessons]
KM	=	knowledge management
NASM	=	National Air and Space Museum
NESC	=	NASA Engineering and Safety Center
NF	=	NASA Form
NPD	=	NASA Policy Directive
NPR	=	NASA Procedural Requirements

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NTRS = NASA Technical Reports Server
PLSS = portable life support systems
SIPI = Southwestern Indian Polytechnic Institute
SKC = Spacesuit Knowledge Capture [Web site]
SME = subject-matter expert
STEM = science, technology, engineering, and math
STI = Scientific and Technical Information
SWME = Spacesuit Water Membrane Evaporator
UTMB = University of Texas Medical Branch

I. Introduction

WITH the successful December 5, 2014 launch of the Orion spacecraft, NASA is one step closer to its mission to explore deep space and harness an asteroid as a precursor to sending humans to Mars within the next two decades. With this mission, the U.S. spacesuit remains a priority for NASA, but to send humans into deep space there are also important ancillary aspects involved, such as astronomy, human factors, crew survival (CS) and escape, and an astronaut's physiological and psychological wellbeing that are tied to his or her environment that lie outside the spacesuit as exemplified in Figure 1. These topics are part of the U.S. Spacesuit Knowledge Capture (KC) Program and are shared with spacesuit developers to design future spacesuits to prepare for human travel into deep space.

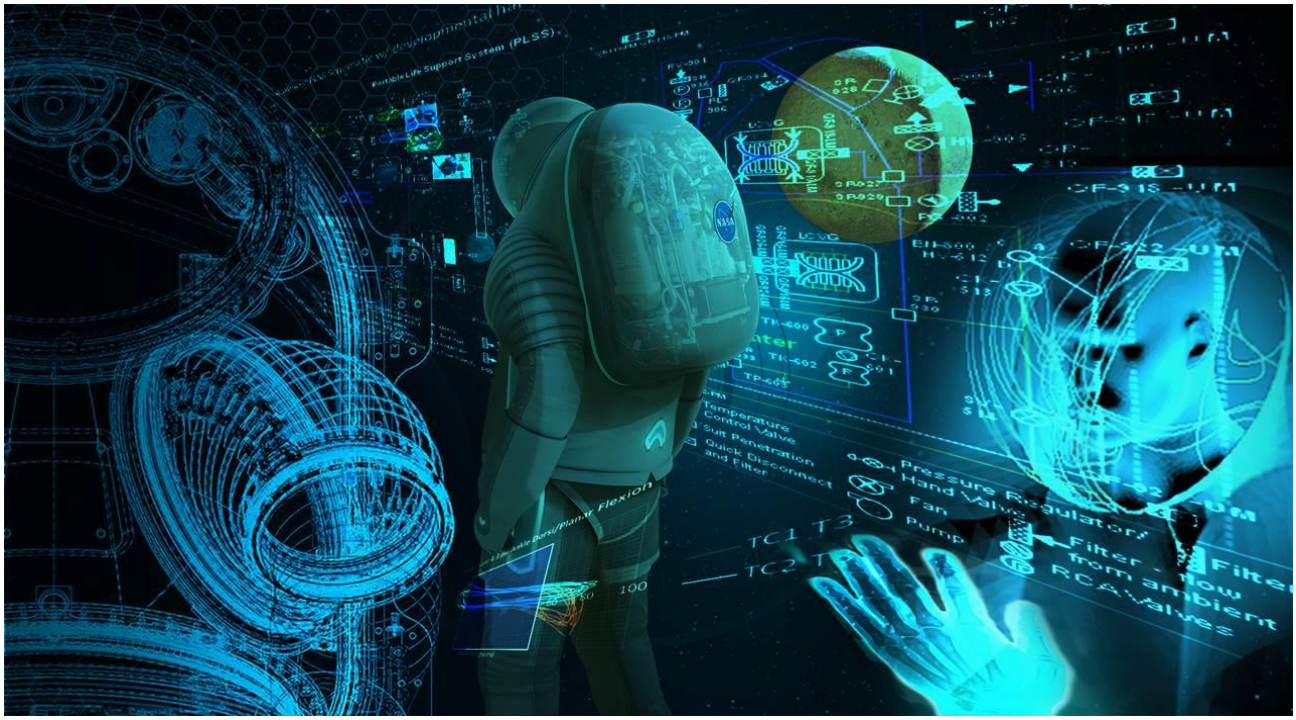

Figure 1. A gallery of ancillary aspects associated with spacesuits (image by Jeannie Corte).

Since its 2007 inception, the U.S. Spacesuit KC Program realized the importance of archiving and sharing historic spacesuit knowledge, and in 2008, the Johnson Space Center (JSC) Policy Directive encouraged JSC organizations to promote knowledge transfer, collaborative sharing, and learning required for the success of the NASA missions; this spurred the KC program.[1] The Space Suit & Crew Survival Systems Branch at JSC manages the U.S. Spacesuit KC program, as a result of a JSC center-wide Knowledge Management (KM) assessment that was completed in May 2007. Although the U.S. Spacesuit KC Program has collected a plethora of valuable information, it is important that these lessons not only get conveyed, but also used. As a way to encourage use of this information, the U.S. Spacesuit KC Program is focusing on having this knowledge readily available to current and future spacesuit developers and technical human mission contributors by disseminating it through NASA and public domains.

The "U.S. Spacesuit Knowledge Capture Status and Initiatives" paper discusses NASA's U.S. Spacesuit KC program from inception through June of Fiscal Year (FY) 2012,[1] and the paper titled "U.S. Spacesuit Knowledge Capture Accomplishments in FY 2012 and 2013" focuses on KC events from July FY12 through FY13.[2] No KC events occurred during FY14. During this period, the emphasis was on processing the existing events to obtain approval for public release and determining a means of accessing this valuable information. Also, in FY14, the NASA Engineering and Safety Center (NESC) became a primary supporter of U.S. Spacesuit KC Program and is helping the program prepare its information to be viewed on five NASA domains, some of which are publically accessible. This paper, "U.S. Spacesuit Knowledge Capture Accomplishments in FY 2014" describes the KC program, identifies the events that were approved for public release, and explains how to access the released events.

II. Approval and Release of the U.S. Spacesuit Knowledge Capture Program Information

It is important to recognize the research and experiences of our spacesuit predecessors and learn from them. The U.S. Spacesuit KC Program collects historical and current spacesuit information and peripheral topics that enhance the development of spacesuits. This program captures this knowledge by hosting events such as lectures, courses, and interviews with subject-matter experts (SME). These SMEs recollect their experience with spacesuits and other ancillary spacesuit-related topics, extrapolate lessons learned, and offer recommendations. This documented information is preserved in written, video, and audio formats and was initially provided to JSC NASA engineers, scientists, and managers to augment their work. However, early in the program, the U.S Spacesuit KC manager realized that other entities such as external aerospace vendors, educational institutions, and the public could benefit from this unique information that is categorized as Scientific and Technical Information (STI). STI is defined as the results (the analyses of data, facts, and resulting conclusions) of basic and applied scientific, technical, and related engineering research and development per NASA Policy Directive (NPD) 2200.1C.[3] Before this information is released to entities outside of NASA, it is sent through an approval process to ensure proper export control.

The means in which the U.S. Spacesuit KC information is collected, managed, disseminated, safeguarded, and archived is governed by NPD 2200.1C. As well, NASA Procedural Requirements (NPR) 2200.2 stipulates that all NASA STI subject to review is required to be approved via the Document Availability Authorization (DAA) review process (using NASA Form (NF)-1676) before being published, disseminated, or presented externally to NASA (or presented in internal meetings or conferences at which foreign persons may be present). The DAA review determines if STI must have restricted access, such as for export-controlled information, proprietary STI, and documents disclosing an invention.[4] The process to disseminate the U.S. Spacesuit KC information involves the U.S. Spacesuit KC administrator completing an NF-1676. The NF-1676 is an electronic form that invokes the DAA process by review and approval of certain technical and managerial representatives. The NF-1676 identifies the event's title, date, author, type of release (journal, electronic, scientific, or technical report series), and specifies whether the content contains new technology development and classified information. After the form is completed and submitted, it is then electronically signed and routed for approval per document JSC-29306.[5] Per NPR 2200.2, the NASA Export Control administrator and the intellectual property attorney (i.e., NF-1676 technology transfer representative signature block), are necessary reviewers and approvers at a minimum. The required technical review and management approval for the U.S. Spacesuit KC information includes that of the author or speaker, the U.S. Spacesuit KC manager, the JSC Crew and Thermal Systems Division (CTSD) Office's (EC) technical representative, the EC export control representative, the JSC Engineering Directorate (EA) technical representative, the technology transfer and commercialization office representative, and a publications representative. An approved NF-1676 signifies that there is no government sensitive information in the content and that the reviewed information may be released to the public.

After the NF-1676 is approved, the information is archived. The process to archive begins with the public-approved information being stored on the EC-owned Spacesuit KC (SKC) Web site. Then the U.S. Spacesuit KC administrator sends the approved SKC information to the NESC. An NESC official creates and uploads the approved documented information to the NESC Web site and creates a package that includes the electronic recording of the event, synopsis, biography, and slides, along with closed caption of the electronic recording. The electronic recording and slides are synchronized for the viewer to see both the recorded presentation and slides simultaneously. After the NESC official processes the information, he or she sends the package to the U.S. Spacesuit KC administrator. The U.S. Spacesuit KC administrator upgrades the SKC Web site with the NESC version, then sends the same information to the following Web sites that also archive recorded U.S. Spacesuit KC information:

1) NASA Technical Library and STI Program's YouTube
2) EA Engineering Academy
3) JSC History Office

The NASA community and public entities can access these events through the NESC Academy, the JSC History Office, and the NASA Technical Library and STI Program's YouTube Web sites. The NASA community can also access these events through the SKC Web site. JSC employees have additional access to these events through the EA Engineering Academy.

III. NESC and Their Contribution

"NASA Engineering and Safety Center's (NESC) mission is to perform value-added independent testing, analysis, and assessments of NASA's high-risk projects to ensure safety and mission success. The NESC engages proactively to help NASA avoid future problems."[6] To carry out this mission, the NESC retains technical experts in a multitude of disciplines across the NASA agency. The spacesuit falls within the Environmental Control and Life Support System's (ECLSS) discipline. Henry (Hank) Rotter, an initial member of NESC as the NASA Technical Fellow for ECLSS and Active Thermal Systems, recognizes the plethora of valuable spacesuit information that the U.S. Spacesuit KC captures, archives, and distributes. He also recognized that the U.S. Spacesuit KC Program includes a tremendous amount of lessons learned that could be shared across the NASA agency. Therefore, in the spring of FY14, Mr. Rotter chose to fund the program, resurrecting it after it lost funding at the beginning of FY14. This funding allows the U.S. Spacesuit KC Program to continue processing its recorded information to be released to the spacesuit community, and make this information readily available to technical experts across the agency through the following Web sites:

1) NESC Academy
2) NASA Technical Library and STI Program's YouTube
3) EA Engineering Academy
4) JSC History Office
5) SKC

The NESC has a collection of electronically recorded events from technical experts of ECLSS and Thermal Systems. Within FY15, the NESC will add to its collection by processing and uploading U.S. Spacesuit KC public-released information. The NESC's library is a conduit that makes this information readily available and ensures that technical experts have key information, especially when the information includes safety. Because of this, the NESC hones in on lessons learned. Much of the U.S. Spacesuit KC program's contents is lessons learned for future spacesuit designers, which fits with Mr. Rotter's discipline area. Giving the spacesuit community access to this valuable information will enhance current and future spacesuit programs.

IV. How to Access U.S. Spacesuit Knowledge Capture Program Knowledge

Out of the 68 recorded U.S. Spacesuit KC events, 36 of these have been public-approved and are being processed to be uploaded to five NASA and public domains: NESC, NASA Technical Library and STI Program's YouTube, EA Engineering Academy, JSC History Office, and SKC. NASA and public entities can access these events through the NESC Academy, the JSC History Office, and the NASA Technical Library and STI Program's YouTube Web sites. Employees within NASA can also access these events through the SKC Web site. JSC employees have additional access to these events through the EA Engineering Academy.

NESC

As a result of the Columbia accident, the NESC was formed in July 2003. The NESC's main purpose is to ensure that NASA's safety and mission assurance organizations have adequate technical expertise and resources for independent, in-depth, technical reviews of NASA's programs. The NESC revealed its mission: "In order to bring the Country's outstanding technical experts to bear on the problems and challenges of NASA programs, the NESC will be comprised of the best engineering expertise from across the Agency and will include partnerships with expert consultants from other government organizations, National Laboratories, universities, and industry."[11] The NESC created a Web site that includes the NESC Academy. The ECLS technical fellow funded the SKC Program to augment the NESC Academy's archives. This technical information is now readily available to technical experts across the NASA agency through the NESC Web site and other viable NASA entities.

NESC Web site: https://nasanesc.webex.com/nasanesc/j.php?MTID=md22992657fd596e700bff4ea0741161f

NASA Technical Library and STI Program's YouTube

The NASA Technical Library is a Web site that operates under the NASA Technical Reports Server (NTRS), which is part of the STI Program. This site stores, organizes, and makes publically accessible NASA public-approved technical, research, and scientific information.

NASA Technical Library Web site: https://ntrs.nasa.gov/

JSC manages the NASA STI Program's YouTube, a publically available Web site that resides within the NASA STI Program, a program that collects, organizes, and preserves technical knowledge and lessons learned from extravehicular activity (EVA), spacesuit, and portable life support systems (PLSS) experts.

"The NASA Scientific and Technical Information (STI) Program was established to support the objectives of NASA's missions and research. It is dedicated to the advancement of aeronautics and space science. This program is essential to help NASA avoid duplication of research by sharing information and to ensure that the U.S. maintains its preeminence in aerospace-related industries and education. The NASA STI Program acquires, processes, archives, announces, and disseminates NASA STI and acquires worldwide STI of critical importance to NASA and the Nation.

The STI Program is a critical component in the worldwide activity of scientific and technical aerospace research and development. Collected from U.S. and international sources, STI is organized according to content prior to being added to the NTRS Registered, which is a world-class collection of STI that includes over 4 million bibliographic records and a growing number of full-text documents. A public interface is available through the NASA Technical Reports Server (NTRS)." [Ref 7]

NASA STI Program's YouTube: http://www.youtube.com/playlist?list=PL30B1C44470174A66&feature=plcp

EA Engineering Academy

The EA Engineering Academy is a Web site that collects and disseminates, to JSC viewers, technical information that includes training, development, and learning resources. It was created in January 2006 with a primary purpose: "to coordinate and focus learning resources within the Engineering Directorate. The EA Engineering Academy works with the Office of the Chief Engineer, the Human Resources Training and Development Office, the University and Research Affairs Office, and other organizations at JSC to accomplish its mission and objectives." [Ref 8]

EA Engineering Academy Web site: http://ea.jsc.nasa.gov/Ea_web/html/emplsrv/academy/index.asp

JSC History Office

The JSC History Office collects, stores, and gives public access to the JSC History Database, JSC Oral Histories, and various recorded JSC history through hundreds of Web sites.

JSC History Office Web site: http://www.jsc.nasa.gov/history/spacesuits/index.htm

SKC

The SKC is a Web site that contains all public-approved U.S. Spacesuit KC Program events for NASA and contractor viewing. It includes links to the U.S. Spacesuit Knowledge Capture Series Catalog Revision A, the EC Share Drive, and spacesuit-related Web sites, which include the EA Engineering Academy, NTRS, and NASA STI Program's YouTube.

SKC: https://oasis.jsc.nasa.gov/orgs/EC/US-SpacesuitKnowledgeCapture/default.aspx

V. Summary of Accomplishments and Events

Since the U.S. Spacesuit KC Program's 2007 inception, 68 events have been recorded and 66 have been submitted to the DAA 1676 process to be approved for public consumption. These events have been delivered in the form of lectures, training courses, lunch-and-learns, workshops, and interviews with spacesuit experts. They are resources to be made readily available to engineers and various technical specialists who can use this information to advance the U.S. spacesuit beyond the boundaries of current technical achievements. These events are electronically recorded and include the presenter's slides and the verbal presentation along with attendees' questions asked during the event.

During FY14, the U.S. Spacesuit KC Program processed the 36 public-approved events (Table 1) to be archived and made publically available by uploading them to the NESC, the NASA Technical Library and STI Program's YouTube, the EA Engineering Academy, the JSC History Office, and the SKC domains. The "U.S. Spacesuit Knowledge Capture Series Catalog Revision A" CTSD–SS–3487 documents all the KC events that occurred since the program's inception through FY13, and includes the event's topic, presenter, synopsis, and each presenter's

biography. The catalog will be available through the NTRS YouTube site [http://www.youtube.com/playlist?list=PL30B1C44470174A66] and is currently available on the SKC site [https://oasis.jsc.nasa.gov/orgs/EC/US-SpacesuitKnowledgeCapture/default.aspx].

Table 1. Public-Approved Events

Date Presented	Presenter	Title of Event
2/22/2008	Garret Fitzpatrick	Gen Y Perspectives
2/28/2008	Bruce Conger	Baseline Constellation PLSS Schematic Functions and Operational Modes
5/20/2008	Joey Marmolejo, Chris Estrada, Chuck Fulcher, and Bryan Peavey	Orlan-M Spacesuit Familiarization Class
6/13/2008	Amy Ross	Gloves 101
8/26/2010	Cinda Chullen and William (Bill) West	Post-Shuttle EVA Operations on ISS
2/17/2010	Lewis Croog	Chinese Spacesuit Analysis
3/15/2010	Dr. Dean Eppler	Conduct of Geologic Field Work during Planetary Exploration: Why Geology Matters
5/20-21/2010	Joe McMann and Mike Rouen	EMU Certification Workshop
6/25/2010	B. Mike Lawson	The Size of the Universe and Where Will We Go?
9/30/2010	Grant Bue & Matthew Vogel	Design and Testing of the Sheet and Hollow Fiber Spacesuit Water Membrane Evaporators
10/28/2010	Jennifer Matty	Joint Mobility
3/31/2011	Gretchen A. Thomas	PLSS 101
6/30/2011	Joe Chambliss	Alternate Approaches to Exploration – The Single Crew Module Concept
8/16/2011	Joe McMann (interviewed by Pica Kahn)	An Interview with Joe McMann: Lessons Learned in Human and Hardware Behavior
10/20/2011	Mallory Jennings	Packing the PLSS
11/29/2011	Carly Watts and Bruce Conger	PLSS 1.0 Breadboard – Schematics

Table 1. Public-Approved Events (continued)

Date Presented	Presenter	Titles of Event
12/6/2011	Joe Kosmo (interviewed by Amy J. Ross)	Farewell Advice
5/10/2012	Tom Sanzone	The Good Old Days of CTSD
1/24/2012	Dr. Scott Parazynski	EVA Physiology & Medical Considerations Working in the Suit
2/23/2012	Dr. Scott Parazynski	TPS Inspection and Repair
3/6/2012	Dr. Scott Parazynski	EVA Skills Training
3/28/2012	Ron Woods (interviewed by Rebecca Wright)	Apollo, Paintbrushes, and Packaging: An Interview with 40-year Spacesuit Veteran Ron Woods
4/19/2012	Ron Woods	Lessons Learned From a Ship-and-Shoot Philosophy
4/26/2012	Ron Woods	The Road to Final Stow
5/14/2012	Dr. Cathleen Lewis (interviewed by Rebecca Wright)	Interview with Smithsonian NASM Spacesuit Curator Dr. Cathleen Lewis
6/19/2012	Grant Bue & Janice Makinen	SWME Development and Testing for the Advanced Spacesuit
6/25/2012	Joe McMann	PLSS Design and Manufacturing Review Debrief
8/14/2012	Juniper Jairala and Robert Durkin	EVA Development and Verification Testing at NASA's Neutral Buoyancy Laboratory
10/16/2012	Joe Chambliss	The Single Habitat Module Concept – A Streamlined Way to Explore
11/6/2012	Jim McBarron	Spacesuit Development and Qualification for Project Mercury
12/4/2012	Jim McBarron	Spacesuit Development and Qualification for Project Gemini
1/29/2013	Jim McBarron	Apollo Block I Spacesuit Development and Apollo Block II Spacesuit Competition
4/10/2013	Kenneth Thomas	Launch, Entry & Abort, Intra-Vehicular Spacesuits
5/6/2013	Dr. Stan Love	Antarctica EVA
7/25/2013	Dr. Paul Abell	Human Exploration of Near-Earth Asteroids
7/31/2013	Dr. Stan Love	Near-Earth Asteroids: Threats and Opportunities

VI. Featured U.S. Spacesuit Knowledge Capture Events

Although the U.S. Spacesuit KC events usually center on the topic of the spacesuit, other important aspects that are related to the spacesuit have been presented at these events. This paper highlights two such topics.

In "The Size of the Universe and Where Will We Go?," B. Mike Lawson illustrated the significance and strengthens an appreciation for Earth and our solar system by showing Earth's perspective to humans and other

planets in our universe and discusses technical capabilities and limitations of human exploration. This also credits reasons to explore space, which is NASA's mission.

To safely travel into deep space, a spacesuit to protect astronauts from the harsh space atmosphere must be designed. Dr. Jonathan B. Clark emphasized that to protect an astronaut, the spacesuit must be readily accessible; the astronaut must be able to don and doff it properly and timely during an emergency. The suit must allow the astronaut to have adequate dexterity and mobility to perform tasks while wearing it.

A. The Size of the Universe and Where Will We Go by B. Mike Lawson

On June 25, 2010, B. Mike Lawson (Figure 1), an avid engineer and amateur astronomer, presented a U.S. Spacesuit KC event that gave a perspective on the size of the universe and asked the question, "Where will we go?"

Figure 1. B. Mike Lawson Throughout His Engineering Career.

This was an entry-level overview for the average space worker who really wants to understand the size of stars and the distance between objects in space. Lawson provided information about familiar orbital objects and elaborated more on galaxies during the discussion. He also explored where humans can go in space and the physical limitations of going there.

Lawson was graduated from the University of Texas with a master of science in mechanical engineering with an emphasis in heat transfer and thermodynamics. He originally worked for General Dynamics, specializing in the environmental control and heat transfer systems for the F-16 fighter aircraft. He came to work for NASA in 1980 and worked on EVA, thermal and environmental control, and life support systems. Lawson retired from NASA in December 2010.

Overview of Spacesuits for Survival and Escape by Dr. Jonathan B. Clark

On September 17, 2013, Dr. Jonathan B. Clark (Figure 2) participated in a U.S. Spacesuit KC event and reviewed the pressure suit used for high altitude and space programs. Dr. Jonathan B. Clark presented "Overview of Spacesuits for Survival and Escape" on September 17, 2013.

Figure 2. Dr. Jonathan B. Clark Contributing to the Space Industry.

Clark reviewed the pressure suit used for high altitude and space programs. Learning objectives included understanding the role that spacesuits play in CS and crew escape and recognizing the design tradeoffs (capabilities and limitations) and concerns that rescue and escape spacesuits have in a survivability situation.

Clark received his bachelor of science from Texas A&M University, and medical degree from the Uniformed Services University of the Health Sciences and is board certified in neurology and aerospace medicine. He worked at NASA from 1997 to 2005 and was a six-time Space Shuttle crew surgeon and was chief of the Medical Operations Branch at JSC. He was a member of the NASA Spacecraft Survival Integrated Investigation Team from 2004 to 2007 and a member of the NASA Constellation Program EVA Systems Project Office Standing Review Board from 2007 to 2010. Before joining NASA, Clark devoted 26 years to active service with the U.S. Navy.

Currently, he is an associate professor of Neurology and Space Medicine at Baylor College of Medicine (BCM) and teaches operational space medicine at BCM's Center for Space Medicine. He is also the space medicine advisor for the National Space Biomedical Research Institute. He is a clinical assistant professor in the Department of Preventive Medicine and Community Health at the University of Texas Medical Branch (UTMB) in Galveston and teaches at the UTMB Aerospace Medicine Residency. Clark is a fellow of the Aerospace Medical Association. He is also medical director of the Red Bull Stratos Project. Clark's professional interests focus on the neurologic effects of extreme environments and CS in space. He accepted this vital role on the Red Bull Stratos team not only to protect Felix Baumgartner from the physical effects of high altitude, but also to establish new protocols to benefit future aviators and astronauts.

VII. Future Outlook for U.S. Spacesuit Knowledge Capture

The U.S. spacesuit legacy has many valuable lessons, but only a fraction of what exists has been shared, preserved, and made accessible to those who can apply them for the advancement of spaceflight. With the NESC's support and encouragement, the U.S. Spacesuit KC Program will host at least nine events during FY15 to continue disseminating this valuable information; seven events will be presented by Jim McBarron and two will be prepared for the Southwestern Indian Polytechnic Institute (SIPI).

Jim McBarron, a retired CTSD chief engineer for EVA projects, will present seven U.S. Spacesuit KC lectures that focus on the spacesuit development for Apollo 7 through 14 missions, as well as the Space Shuttle Extravehicular Mobility Unit (EMU) spacesuit development. With over 50 years of experience with NASA spacesuit development and operations, as well as the U.S. Air Force pressure suit, Mr. McBarron will also share lessons learned from this experience. This information will be stored electronically on the NESC, along with the

NASA Technical Library and STI Program's YouTube, the EA Engineering Academy, the JSC History Office, and the SKC Web sites.

The SIPI proposal that the U.S. Spacesuit KC Program won in FY14 will have robotic experts deliver two presentations to SIPI to facilitate the study of science, technology, engineering, and math (STEM) education. These presentations will be knowledge capture (K-CAP) lessons provided to SIPI students who will have remote access through online meetings using software applications such as WebEx as these lessons are presented. During these lessons, students will have the opportunity to ask questions to the SMEs presenting the lesson. These sessions will be electronically recorded for SIPI to use in the future and for reference. Recordings will also be stored on compact discs to make the material accessible to educators and students. The students may also access lessons and other non-sensitive technical lectures deemed public releasable on the NASA YouTube site.

The individual K-CAP lessons will focus on particular subjects. For example, if the learning tools are LEGO robotic mechanisms, a NASA expert will provide a K-CAP lesson on robotics. The lessons will be adaptable and targeted to the interest of the students or academia.

With the U.S. Spacesuit KC program's experience in the KC field, including its institutional processes to collect, store, and disseminate valuable stories, lessons learned, and knowledge from their internal STEM experts, it will benefit minority high school students as it provides valuable insight into the context of experiences.

A NASA JSC-trained KC manager and the NASA JSC robotic mentor will guide the K-CAP lessons. A K-CAP administrator will assist the NASA JSC knowledge manager and robotic mentor in managing the K-CAP program. By working together, NASA, along with the students and educators, can not only sustain, but increase America's interest in STEM and make possible what is now thought to be impossible. This work will be funded via a NASA grant.

A. Apollo and Space Shuttle Spacesuit Events by Jim McBarron

In FY15, seven U.S. Spacesuit KC events will be presented by Jim McBarron, a former NASA employee who worked with spacesuits for all NASA flight programs including Mercury, Gemini, Apollo, Apollo-Soyuz Test Project, Skylab, Shuttle, and the International Space Station (ISS):

1) Early Apollo Spacesuit Development, A-7L Suit Requirements, and Design Details
2) Apollo A7L Suit Certification, and Apollo 7-14 Missions' Suit Details
3) Apollo A-7LB Spacesuit Development for Apollo 15 through 17 Missions
4) Apollo Spacesuit Modifications and Development for the Skylab 1/2 through 4 Missions
5) Apollo Spacesuit Modifications and development for the Apollo Soyuz Test Space Shuttle
6) Space Shuttle EMU Spacesuit Development for Initial Shuttle Flights
7) Space Shuttle EMU Spacesuit Development for the International Space Station

B. Southwestern Indian Polytechnic Institute Knowledge Capture

There is a trove of information within NASA that can facilitate the study of STEM education. Sharing this information with young minorities such as Native Americans and Hispanic students within the United States is critical to help promote and sustain the interest and education of STEM subjects.

As part of NASA's JSC commitment, NASA created a way for the students to learn from experts as the students perform their projects through live learning sessions known as K-CAP lessons. The U.S. Spacesuit KC program will host K-CAP lessons with SMEs. The students will have remote access through online meetings using software applications such as WebEx. The students can learn by participating in the live K-CAP lessons and asking questions to SMEs. As the lessons occur, the U.S. Spacesuit KC program will digitally record them for students to have electronic access to the information for future use and reference. Recordings will also be stored on compact discs to make the material accessible to educators and students. The students may also access lessons and other non-sensitive technical lectures deemed public releasable on the NASA YouTube site.

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interest in STEM and make possible what is now thought to be impossible. This work will be funded via a NASA grant.

VIII. Conclusion

KM is a strategic objective for NASA, and sending humans deeper into space than ever before is a primary mission of NASA. The U.S. Spacesuit KC program has proved to be vital in meeting this strategic objective, and with it, supports NASA's deep-space mission. This program has provided a mechanism for retaining pertinent knowledge of the spacesuits and is especially timely as a new spacesuit is currently being designed, assembled, and tested, and the mission architecture is being established. Knowledge is being shared and learning is being encouraged to help improve performance, facilitate innovation, eliminate redundant work, potentially reduce "training time," and help adapt to a changing environment in space exploration. The knowledge being archived comes from the knowledge of those who learned before us so those who come after us can continue to explore, push the envelope, and live in space so that we can go farther, do better, and know more in the process. This paper provides a status and reveals initiatives associated with the program so that the information is communicated and preserved. Perhaps the greatest challenges facing the U.S. Spacesuit KC program consist of first making sure that those who could benefit from it know of its existence, second, that they know how to use it, and third, that they understand the importance of archiving spacesuit history so that future engineers and managers can benefit from our nation's investment. The value of KC was best expressed by the parent of an elementary student: "We don't always reach our expectations and we don't always win; it's the lessons from the journey that we carry with us [that] mean the most over time."

In a 2010 visit to the Kennedy Space Center, President Barack Obama discussed NASA's next chapter: "Critical to deep space exploration will be the development of breakthrough propulsion systems and other advanced technologies. So I'm challenging NASA to break through these barriers."[9] To break through barriers and deliver advanced technologies in spacesuit design, the U.S. Spacesuit KC Program's collection of valuable unique information is being tapped.

Although NASA's workforce (civil servants and contractors) is only 26.6% of that during the Apollo era (approximately 218,000 in June 1969[10] compared to approximately 58,000 in January 2015[11]), the information resources are greater than ever in NASA's history. With the abundance of KC, the time is ripe for spacesuit designers to use this resource to help prepare astronauts for deep space missions. NASA's goal is to take humans farther into space than that of Apollo; the U.S. Spacesuit KC goal is to capture and make significant knowledge accessible to spacesuit designers, scientists, and any entity that will enhance the opportunity to increase NASA's ability to reach its goal. Making this knowledge accessible to scientists, designers, engineers, and technologists who will apply it to advance NASA's space program and help make it possible for astronauts to reach and endure the deep space environment will increase this information's value and help keep the United States the world's leader in space science.

Acknowledgments

The authors of this paper would like to thank those who are hidden behind the scenes, but provide incredible service in recording U.S. Spacesuit KC events; namely, Jim Hansen and Matthew Mcgee. We would also like to thank Hank Rotter and SIPI for their commitment to continue the U.S. Spacesuit KC Program. Without the support of these individuals, the U.S. Spacesuit KC Program would not be possible.

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